



A new energy future for Montana, Idaho, South Dakota, Wyoming and the nation.

Big Sky Carbon Sequestration Regional Partnership

www.bigskyco2.org

Fourth Annual Conference on Carbon
Capture & Sequestration
May 2-5, 2005



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Composition

Research Institutions (universities, labs, others)
State, federal agencies (includes USDA, USGS, NASA)
Industry members including major power producers
(Energy Northwest, Sempra Generation), engineering
firms, resource owners
Carbon trading entities (NCOC)
Outreach Education partners
Tribal Nations and Councils (3+)
International Collaborators (includes Canada, Norway,
India, China)

Total number of partners: 40+



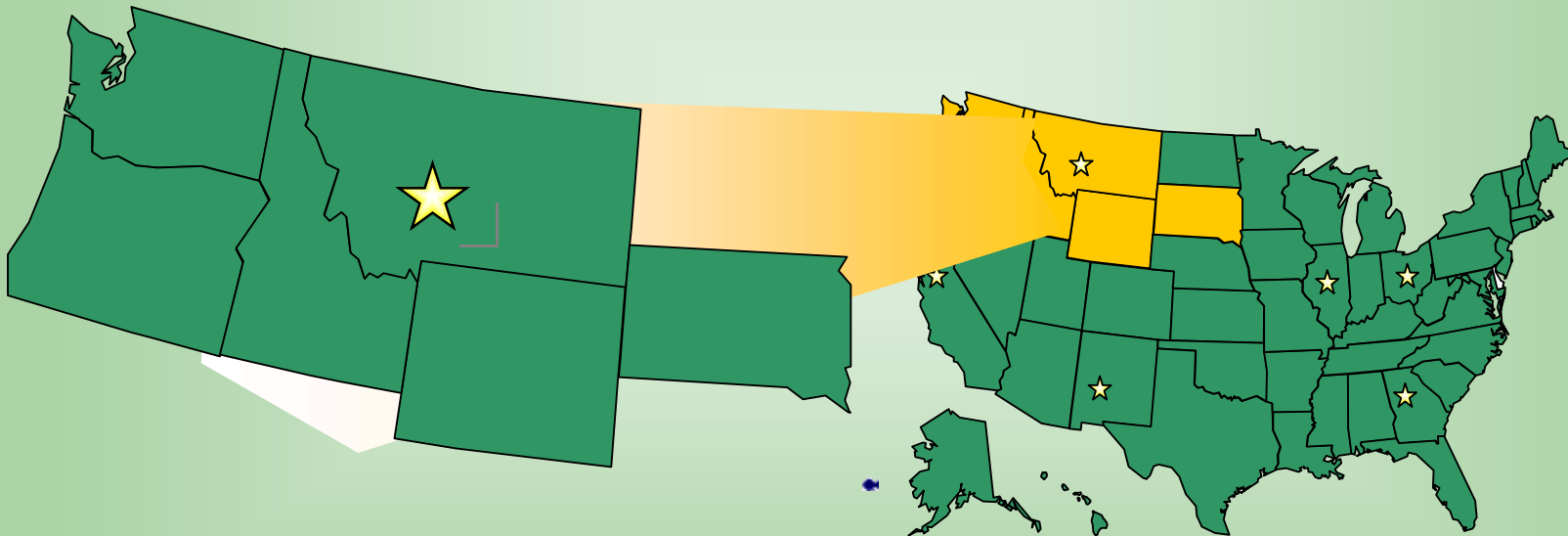
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CANADA:	BioCap Canada, Alberta Utility and Energy Board Semiarid Prairie Agricultural Research Centre (via the Jackson Hole Center for Global Affairs)
CHINA:	Institut de Physique du Globe de Paris
FRANCE:	National Geophysical Research Institute
INDIA:	under negotiation (MMV technologies)
JAPAN:	Det Kongelige Olge - Og Energidepartement
NORWAY:	Institute for Energy Technology Norwegian University of Science & Technology Research Council of Norway, Hanshaugen SINTEF Petroleum Research
NETHERLANDS:	Wageningen Universiteit, Lab of Soil Science and Geology
RUSSIA:	Vernadsky Institute of Geochemistry and Analytical Chemistry of the Russian Academy of Sciences



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Partnership area as we move into Phase II
(excluding international collaborators)





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Outline

- Context
- Phase I experience
- Phase II – key elements



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Context

- “Wealth of sinks, wealth for future energy supplies”
- Energy security, economic growth
- 40% of US coal resources are in Big Sky region
- Marriage of good science-based technologies with good economics



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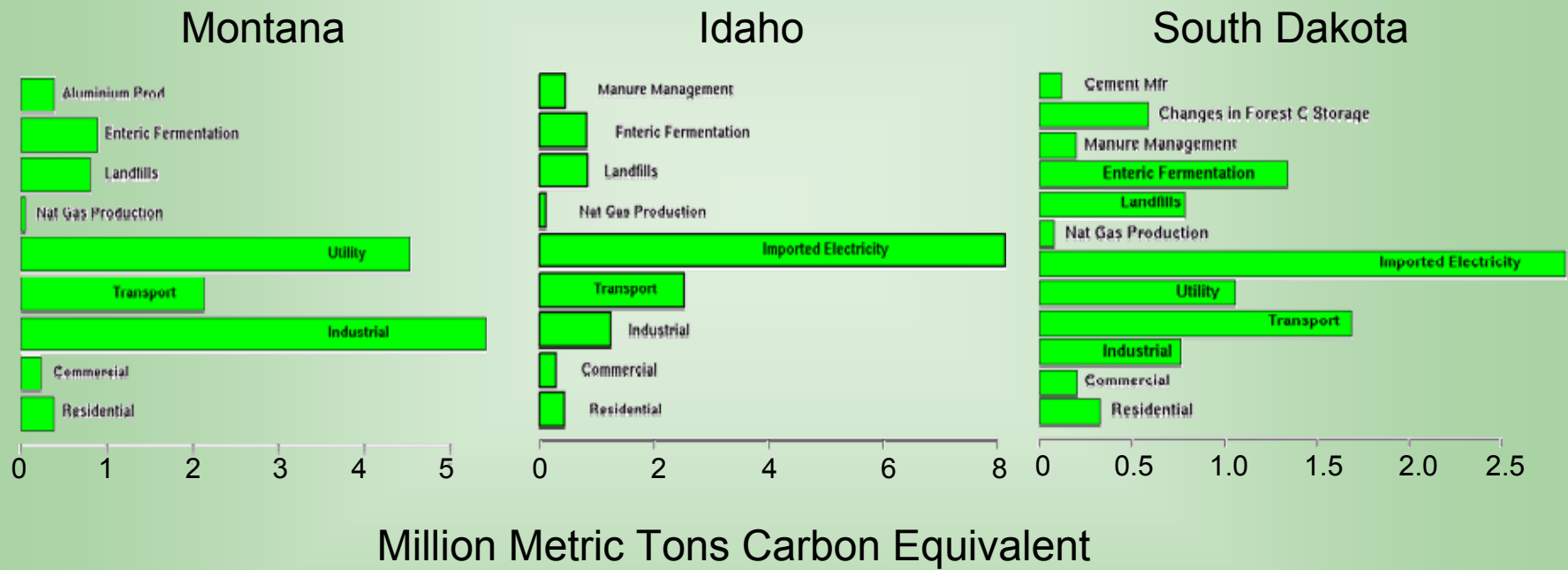
Phase I Experience

- **Identify, assess and catalogue C sources and promising geological and terrestrial sinks**

Sources

- Point locations for major utility and industrial emitters

Major Categories (> 0.5 MMTCE)

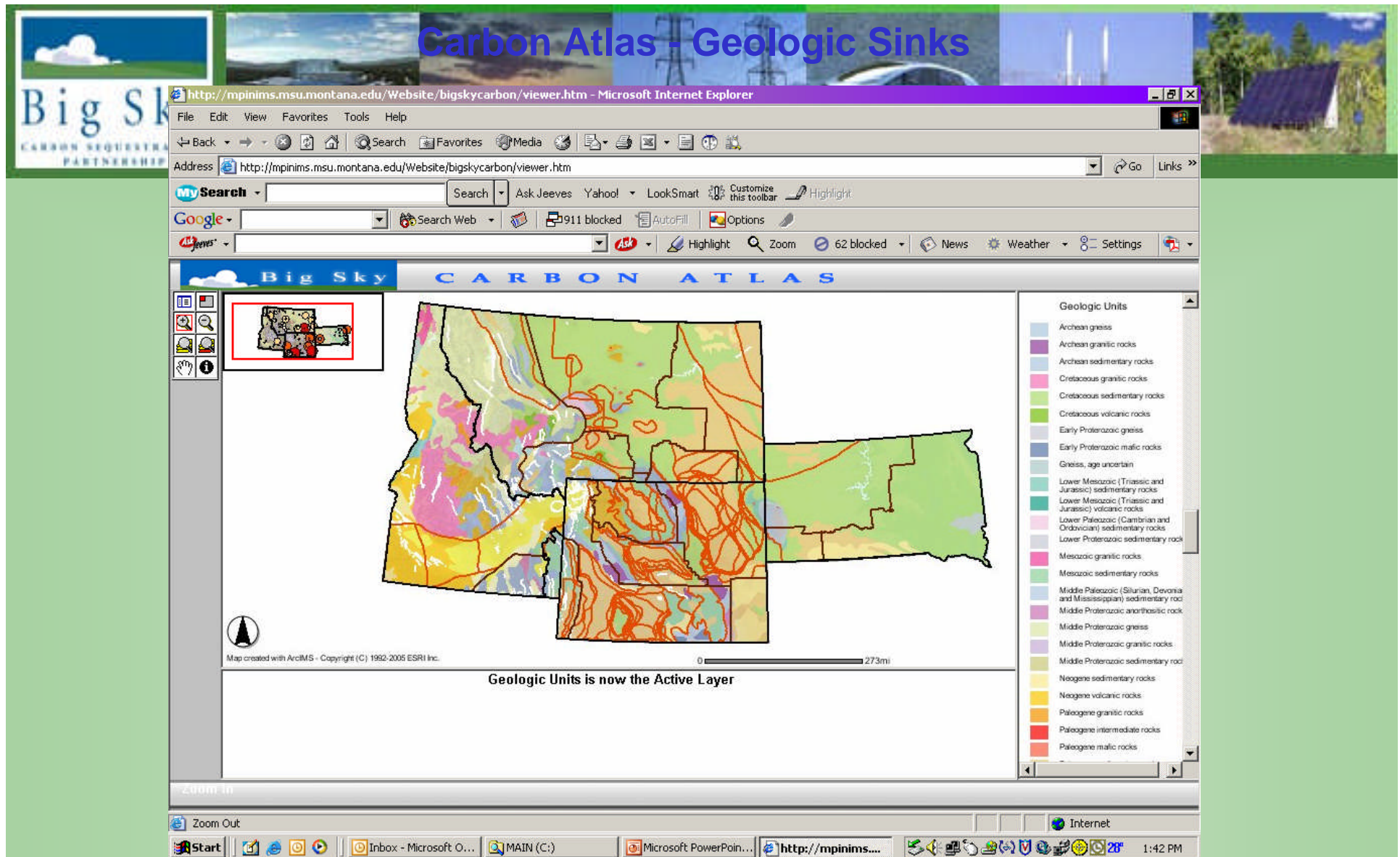




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Geologic Sequestration Phase I

- Develop regional carbon atlas from existing sources
- Assess unique rock types with emphasis on mineralization and other processes that transform CO₂ to carbonate alkalinity and/or solids
- Evaluate the potential of regionally abundant basalt rocks for sequestration



Includes:

- NOGA regions
- NOGA provinces
- Plays
- Quarternary faults and folds
- Geologic Units

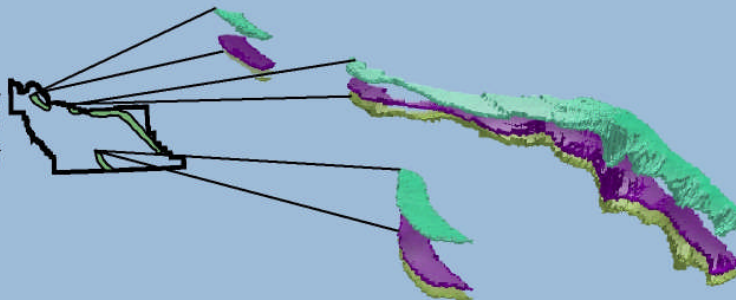


Results from Model Calculations for Wind River Basin Province

3501

Play area=763389.2612 acres

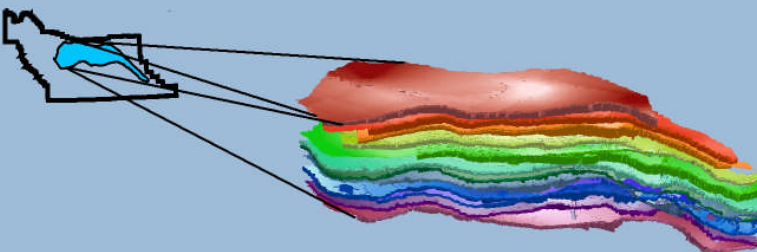
Formation	Average Thickness	Average Porosity	Water Saturation	Salinity (ppm)	Oil and Gas Sequestration Volume	Saline Aquifer Sequestration Volume
Frontier	802-R	12	62	21731	2,163,991	3,313,867,333
Phosphoria	334-R	10	35	9920	2,317,337	1,393,784,596
Tensleep	364-R	16.3	32	3303	4,634,202	1,552,839,294
Play Sum (metric tonnes)					9,115,530	6,260,491,222



3503

Play area=1326859.671 acres

Formation	Average Thickness	Average Porosity	Water Saturation	Salinity (ppm)	Oil and Gas Sequestration Volume	Saline Aquifer Sequestration Volume
Wind River	2472-R	10	50		4,969,416	16,119,150,019
Fort Union	2499-R	12	61	8866	13,667,362	35,013,685,747
Lance	2850-R	5.4	70	6230	5,275,005	13,062,146,970
Mesaverde	1230-R	2.5	44.4	10841	748,746	3,989,166,830
Fales	196	5.4	68		651,933	659,534,093
Cody	2924-R	11	46	10259	14,177,203	23,084,424,771
Frontier	802-R	9.2	59	21731	2,061,457	6,778,271,960
Muddy	49-R	4	60	8758	63,547	261,307,368
Cloverly	102	14.5	56	2176.8	435,243	1,425,611,588
Morrison	232-R	13.5	37.5	38983	1,288,657	2,672,623,717
Nugget	250-R	12	60		578,430	1,221,597,685
Phosphoria	334-R	10	35	9920	1,052,229	3,144,620,992
Madison	384-R	12	44	390	1,733,251	4,303,974,639
Play Sum (metric tonnes)					46,702,478	111,736,116,379



Formations

Wind River	Muddy
Fort Union	Cloverly
Lance	Morrison
Mesaverde	Nugget
Fales	Phosphoria
Cody	Tensleep
Frontier	Madison

3504

Play area=1129577.118 acres

Formation	Average Thickness	Average Porosity	Water Saturation	Salinity (ppm)	Oil and Gas Sequestration Volume	Saline Aquifer Sequestration Volume
Muddy	49-R	4	60	8758	79,458	174,307,234
Play Sum (metric tonnes)					79,458	174,307,234



Wyoming



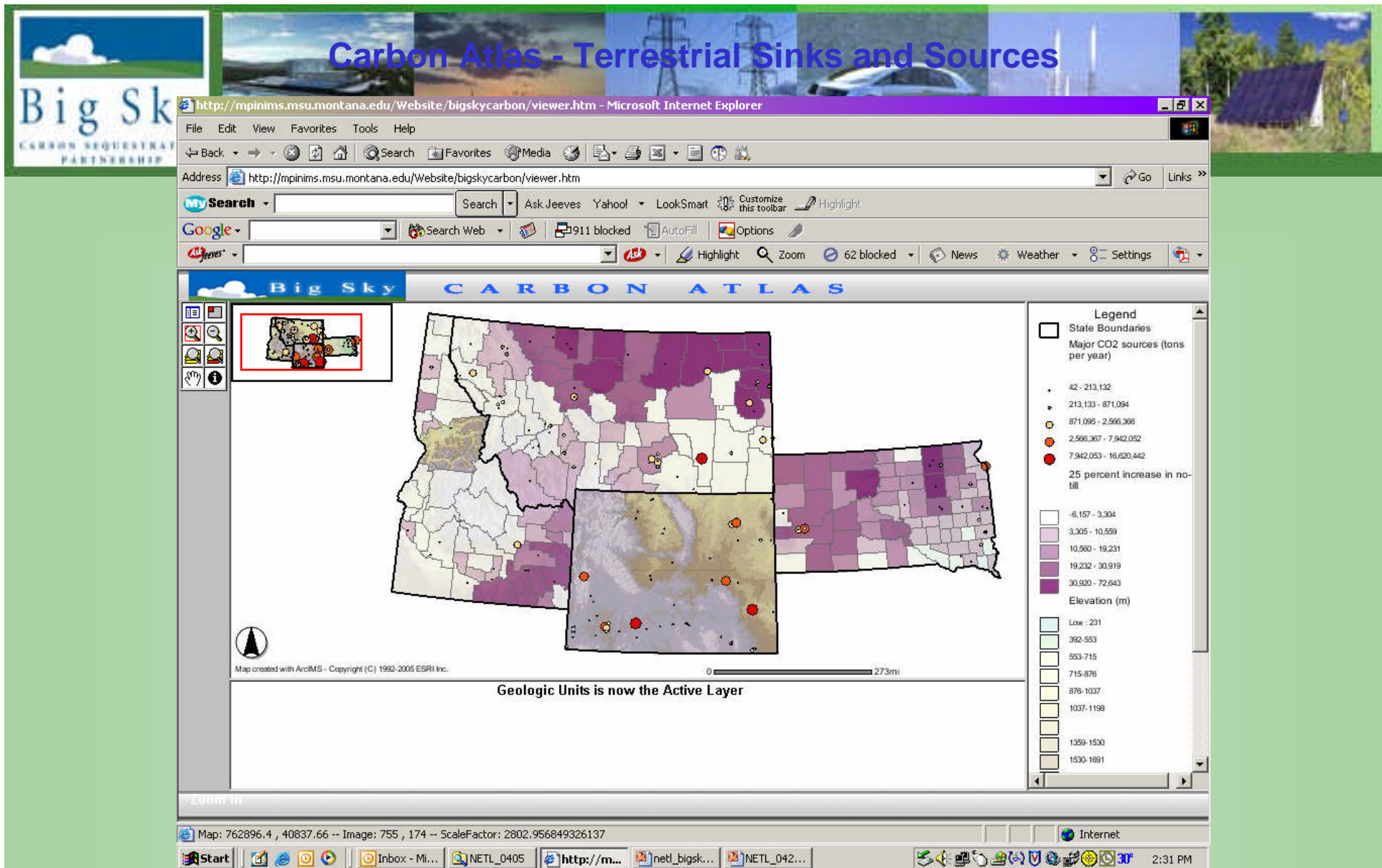
Note: For aesthetic purposes, formation surfaces are not proportionately spaced.



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Terrestrial Sequestration Component

- Bridge to Geological sequestration
- Technical potential
- Economic potential
 - finding those elusive supply curves for carbon
- Producer decision-support framework(s)
- Pilot studies for carbon trading
- Project Workbook for Reforestation
- Collaboration with USDA, EPA, NASA



- Projected yearly CO₂ capture under the '25% increase in no-till' scenario
- Other scenarios include: 25% increase in CRP and 25% of current CRP to no-till
 - Using Century Model Runs



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Phase I Experience

- Identify, assess and catalogue C sources and promising geological and terrestrial sinks
- **Develop an economic and risk assessment framework to optimize region's C sequestration portfolio**



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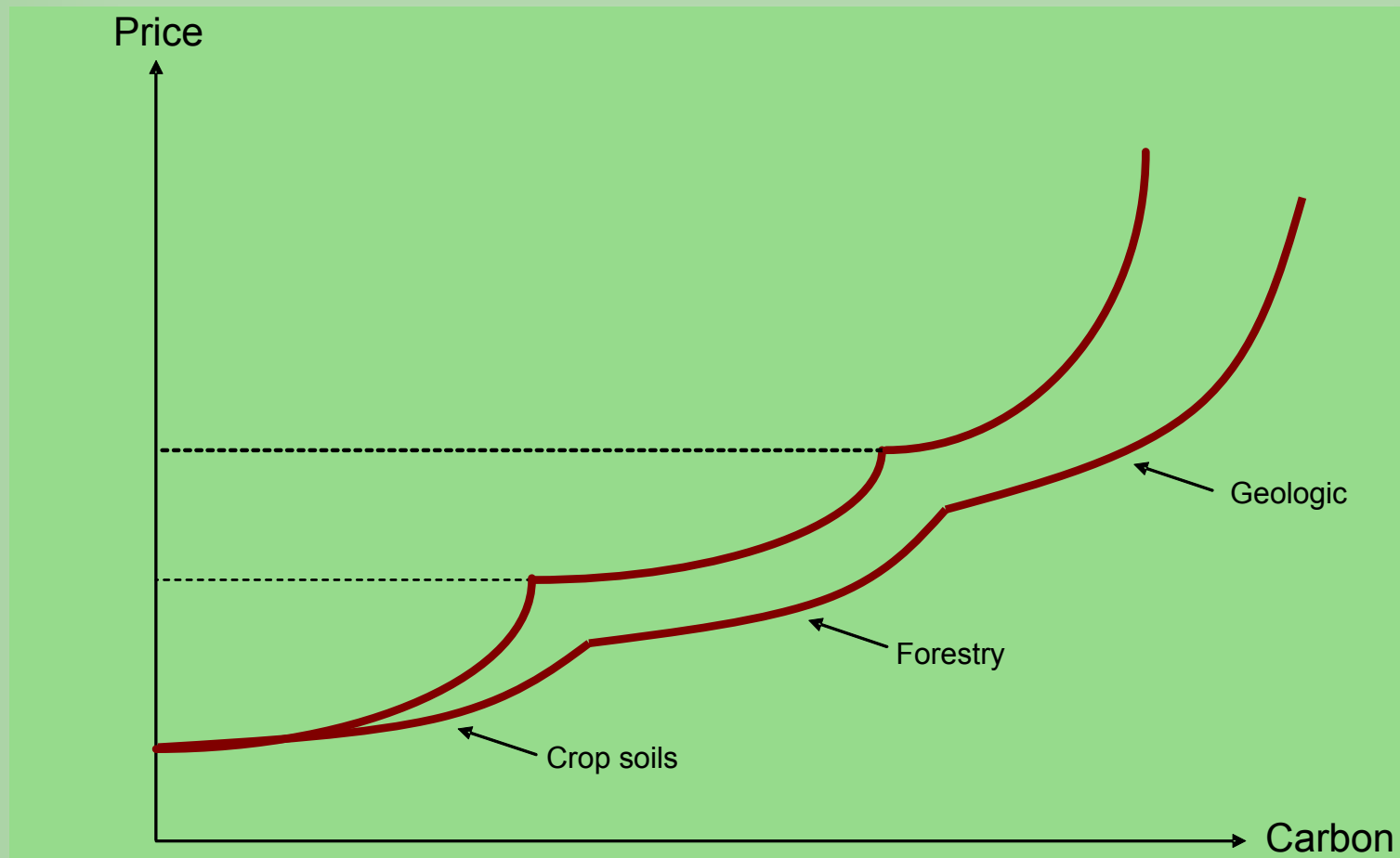
MMV activities

- Storage capacity needs to be matched with storage integrity
- MMV is seen as tools, means to end
- Coordinate MMV outputs with the following actions:
 - Regulatory Operations and Compliance,
 - Community Outreach and Communications,
 - GIS Systems and Predictive Applications and
 - Economic and Risk Assessment Modelling—making better decisions.



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Regional Carbon Supply Curve





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- **Carbon trading program– market-based storage methods and verification protocols**



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Road testing the Carbon Portfolio...

...Implementing Pilot Terrestrial Carbon Sequestration Projects Placed On Emerging Markets

- project planning handbook;
- listing agreements;
- contracts;
- vintage credit portfolio design;
- assessment of forestry & agroforestry potential in the region;
- and volume tables for key agroforestry species



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Phase I Experience

- Identify, assess and catalogue C sources and promising geological and terrestrial sinks
- Develop an economic and risk assessment decision support framework to optimize region's C sequestration portfolio
- Carbon trading program— market-based storage methods and verification protocols
- **Public education and outreach**



Webpage Highlights:



- Carbon Atlas
 - Primary Source Emissions Statistics
 - Partnership Publications/Presentations/Reports
 - Partnership Management/Key Contacts/Technical Leads
 - Terrestrial, Geologic and GIS Links, educational material



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Phase II and beyond

Objectives:

- utilize resource base to meet growing energy demand with portfolio of advanced technologies + sequestration opportunities (transformative technologies)

Design:

- work with industry partners so that field test are effective, relevant to commercial development needs, and transferable
- Storage capacity and storage integrity



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Phase II and beyond

Geological Sequestration Efforts:

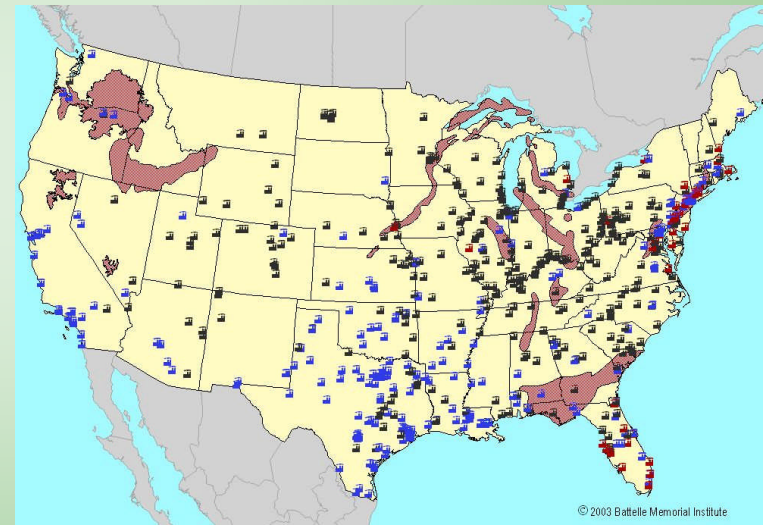
- **Utilize CO₂ reactivity to enhance sequestration**
 - **Basalt pilot scale injection (form solid phase carbonates)**
 - **Carbonate aquifer assessment (develop carbonate alkalinity)**
 - **Deep coal bed exchange (separate and sequester from flue gasses)**
- **Industry partner: Energy Northwest and the IGCC power complex**
- **Transfer results to the Nation –**
 - **National Mafic/basalt rock atlas**



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CO₂ Sequestration in Basalts

- Major flood basalt formations exist throughout the world
 - Important role in global carbon cycle
 - Implicated in past climate change events
 - Not widely considered as a geological sequestration option
- Over 30 years and >\$400M of prior DOE investment in understanding basalt/aquifer systems that can be applied to carbon storage
- Capacity and Retention
 - Columbia River Basalt Group covers 164,000 km², >174,000 km³
 - Chemical makeup favorable for mineralization reactions
 - Lateral connectivity of interflow zones but limited vertical connectivity between flows
- Water Resource Implications
 - Upper aquifers (<300 m) are major source of water
 - Deeper aquifers contain non-potable water

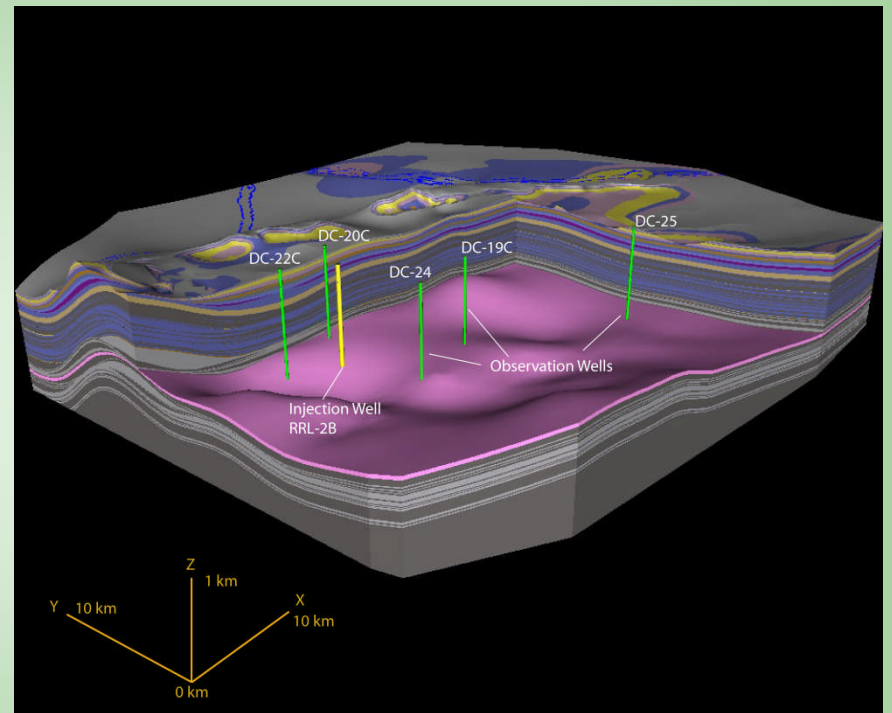




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Basalt Pilot Proposal

- Utilize existing deep well infrastructure on Hanford site to minimize drilling costs for injection and monitoring
- Collect core samples post-injection to verify rapid mineralization rates observed in laboratory testing
- Validate supercomputer simulations of CO₂ dispersion, dissolution, and trapping in basalt using suite of geophysical, hydrologic, and tracer methods





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Phase II and beyond

Terrestrial Sequestration Efforts:

- Advance Phase I market-based storage and verification protocols
- Cropland, forestland and rangeland field test sites and carbon portfolios in conjunction with **Sempra Generation**, tribal members, and landowners
- Compliance with 1605b National Greenhouse Gas Registry and MMV protocols



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Key Components

- Develop a joint venture with the National Intertribal Environmental Council to implement a national tribal portfolio.
- Work with Nat Source of New York, and CCX of Chicago to take projects to CCX or other emerging markets
- Design and implement a C sequestration strategy for **Sempra Generation** for 25,000 mt of credits each year, expand to 1Mmt/yr portfolio
- seating a Technical Standards Committee prior to start of Phase II for the purpose of setting NCOC's project standards for the portfolio projects.



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Phase II and beyond

Integration Efforts:

- Regional C supply curve (geological and terrestrial sequestration options)
- Regional Technology Implementation Plan
- Natcarb efforts
- Ruckelshaus Institute – env reg and NEPA process
- Work with CSLF
- Share results with other partnerships



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Summary

- “Wealth of sinks, wealth for future energy supplies”
- Marriage of good science-based technologies with good economics
- Demonstration Phase II efforts are strongly supported and leveraged by Industry partners and State Governors

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